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1. Your reference — D. BHATOOLAUL 3-15-3

2. Patent application number *(The Patent Office will fill in this part)* — 18 MAR 1999 — **9906198.8**

3. Full name, address and postcode of the or of each applicant *(underline all surnames)*

   LUCENT TECHNOLOGIES INC.
   600 Mountain Avenue
   Murray Hill,
   New Jersey 07974-0636
   United States of America

   Patents ADP number *(if you know it)* — 7039555061

   If the applicant is a corporate body, give the country/state of its incorporation — Delaware U.S.A.

4. Title of the invention

   IMPROVED RANDOM ACCESS CHANNEL

5. Name of your agent *(if you have one)* — D.J. Williams

   "Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*

   Lucent Technologies UK Limited
   5 Mornington Road
   Woodford Green,
   Essex IG8 OTU
   England

   Patents ADP number *(if you know it)* — 699 3869001

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number

Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

Number of earlier application	Date of filing *(day / month / year)*

8. Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if:*
   a) any applicant named in part 3 is not an inventor, or
   b) there is an inventor who is not named as an applicant, or
   c) any named applicant is a corporate body.
   See note (d))

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Continuation sheets of this form	
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Claim(s)	1 ✓
Abstract	–
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Priority documents	–
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Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*	–
Request for preliminary examination and search *(Patents Form 9/77)*	–
Request for substantive examination *(Patents Form 10/77)*	–
Any other documents *(please specify)*	

11. I/We request the grant of a patent on the basis of this application.

Signature

Date 18th March 1999

12. Name and daytime telephone number of person to contact in the United Kingdom — D.J. WILLIAMS 0181-504 2824

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Williams, David (David)

From: Williams, David (David)
Sent: Thursday, March 18, 1999 10:45 AM
To: Chen, Xiaobao X (Xiaobao)
Subject: Chen 5

Xiaobao

I attach the text for Chen 5. I am not yet 100% happy about the description for this fifth idea. Therefore I have delayed putting the claims together for this case until I receive your initial comments on the text.

Chen 5.doc

David

IMPROVED RANDOM ACCESS CHANNEL

A quick acquisition indication for message on Random Access Channel (RACH) for UMTS is first proposed using Acquisition Indication Channel (AICH). With the proposed scheme, random access delay is expected to be decreased, hence reduce delay for both call set-up and short message transmission. It also reduces hardware cost and make an efficient use of both physical layer h/w and higher layer s/w resources.

RACH Message Acquisition Indication for UMTS

RACH Structure and RACH Message

In UMTS, The RACH transport channel is mapped to the Physical Random Access Channel (PRACH). RACH transmission is based on a slotted ALOHA approach, i.e. a MS can start the transmission of the PRACH at a number of well-defined time-offsets. The different time offsets are denoted access slots and are spaced 1.25 ms apart as illustrated in Figure 1.

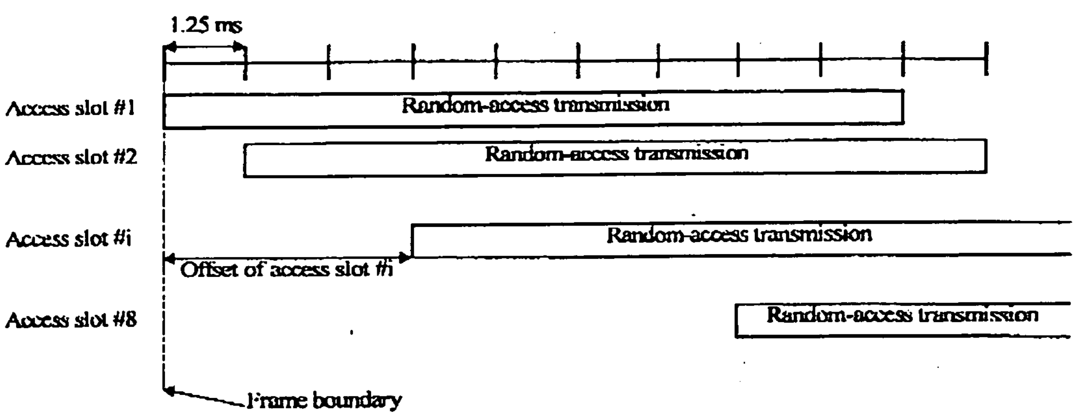

Figure 1: PRACH Access Slots Structure

The structure of the random-access transmission is shown Figure 2. The random-access transmission consists of one or several preamble parts of length 1 ms and an access burst which contains the preamble part and a message part of length 10 ms.

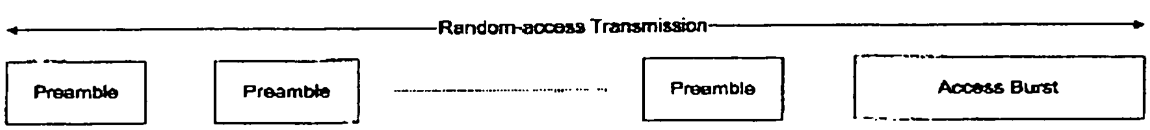

Figure 2: Structure of the Random-Access Transmission

The structure of the access burst is shown in Figure 3. There is an idle time period of length 0.25 ms between the preamble part and the message part. The idle time period allows for detection of the preamble part and subsequent on-line processing of the message part. {Whether only message is sent or an access burst consisting of preamble and message parts is still under discussion}

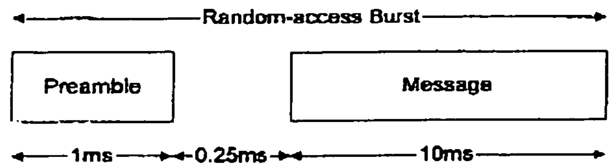

Figure 3: Structure of the Access Burst

RACH message part consists of a data part, corresponding to the uplink DPDCH, and a Layer 1 control part, corresponding to the uplink DPCCH, see Figure 4. The data and control parts are transmitted in parallel. The data part carries the Layer 2/Layer 3 messages requesting for radio resources or user packet. The spreading factor of the data part is limited to SF∈{256, 128, 64, 32} corresponding to channel bit rates of 16, 32, 64, and 128 kbps respectively. The control part carries pilot bits and rate information, using a spreading factor of 256. The rate information indicates which channelisation code (or rather the spreading factor of the channelisation code) is used on the data part.

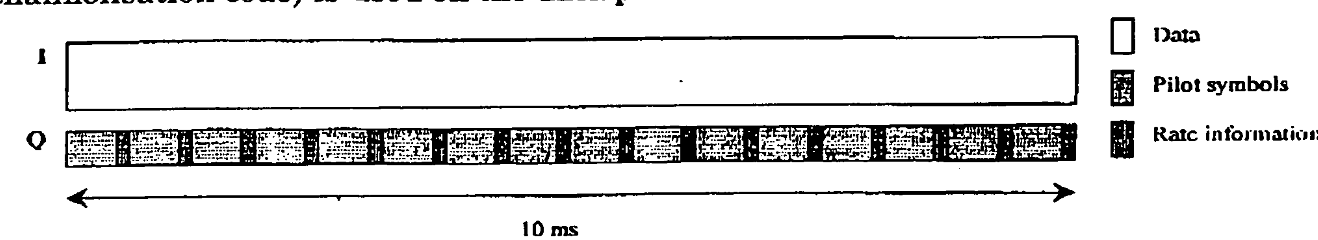

Figure 4: Message Part of the Random-Access Burst.

AICH Preamble Acquisition Indication

Preamble power ramping is employed for RACH transmission, the following procedure is used by a random access request:

1. After cell search and synchronisation, the MS reads the Broadcast Control Channel BCH to get information about:
   - The preamble spreading code(s)
   - The available signatures
   - The available access slots

- The available spreading factors for the message part
- The uplink interference level in the cell
- The primary CCPCH transmit power level

2. The MS selects a preamble spreading code and thus the message scrambling code.

3. The MS selects a preamble signature and use it to determine the primary node of the channelisation codes used by the message part of the access burst.

4. The MS selects a channelisation code (corresponding to a spreading factor) for the message part.

5. The MS estimates the downlink path loss (by using information about the transmitted and received power level of the primary CCPCH), and determines the required uplink transmit power (by using information about the uplink interference level in the cell).

6. The MS implements the dynamic persistence algorithm by:

   - Reading the current dynamic persistence value from the BCH.
   - Perform a random draw against the current dynamic persistence value.
   - Defer transmission for one frame and repeat step 6 if the result of the random draw is negative, otherwise proceed to step 7

7. The MS randomly selects an access slot from the available access slots.

8. The MS transmits its preamble at a negative power offset relative to the estimated uplink transmit power.

9. The MS waits for an acquisition indication (on the AICH) from the network side. If none is received within a predefined time-out period, the MS transmits the preamble again but with a smaller power offset and a re-selected preamble signature.

10. Step 8 is repeated for a predetermined number of retransmission or until an acquisition indicator is received from the network side which indicates the acceptance by the network side of the preamble at that power offset.

11. If an acquisition indicator is received on the AICH in Step 9, the random access burst is transmitted in the next available access slot.

12. A positive acknowledgement will be sent on FACH the network side to the MS if the reception of the message part is successful. If no acknowledgement is received by the MS (negative ACK, or

NACK), Step 5 onwards is repeated, until a positive acknowledgement is sent out on FACH from the network side.

From the above procedure, one can see that in Step 12 even if MS's message part is corrupted (in the sense that the message part can not pass the CRC check in BTS), MS still needs to wait for a period of time (waiting time, WT) until it makes sure there will be no ACK on FACH coming.

In the prior art, the waiting time WT can be very long. Once BTS does CRC checking to the received message, physical layer in the BTS will always indicate its higher layer, Layer 2 (Data Link Layer), about the outcome of the CRC checking. If message part is successfully received by the BS (CRC checking passed), BS physical layer will indicate Layer 2 and Layer 2 will put positive ACK onto FACH transmission. Then the MS will be informed by the successful reception. Note that Layer 2 for UMTS is likely located in BSC, meaning that the waiting time WT can be even longer than the case there Layer 2 is located in BS. This process is shown in Figure 5. If the message is corrupted, a negative CRC result will be indicated to the Layer 2. Layer 2 will not schedule any acknowledgement transmission on the FACH. MS, after a certain time-out, will repeat Step 5 onwards. The latency is obvious.

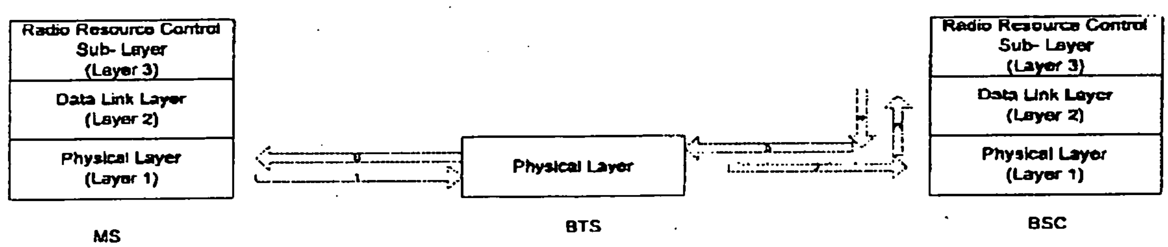

Figure 5 Layer 2 is involved for acknowledging message part in prior art

In summary, in prior art AICH is used to acknowledge random access preamble, whereas FACH is used to acknowledge message as shown in Figure 6.

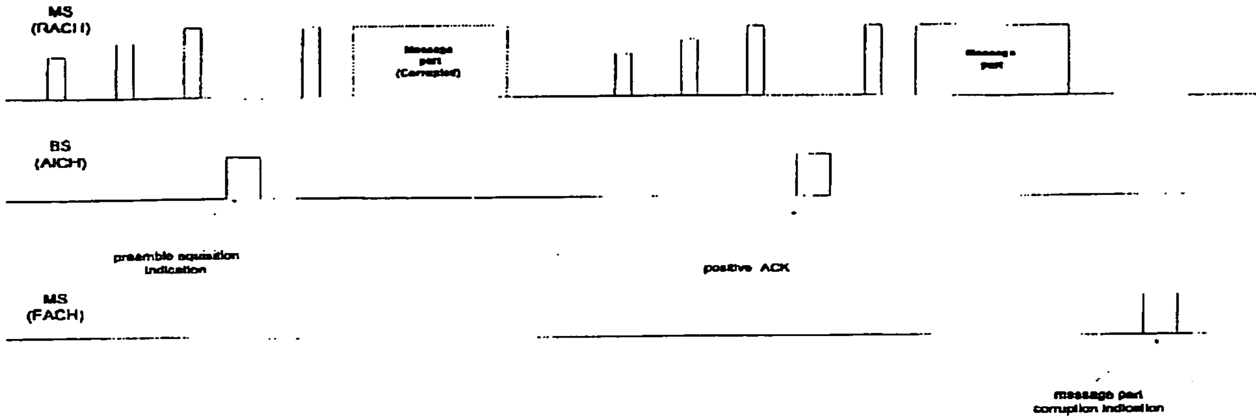

Figure 6 FACH acknowledges the successful message reception

Improvement 1: use of AICH to acknowledge both preamble and message

To reduce latency, we propose to use AICH to acknowledge both preamble and message.

- The AICH acknowledgment to the preamble process is basically the same as the prior art.
- Once physical layer in BS detects the CRC checking failure for the message part (e.g., message part is corrupted), it won't indicate to Layer 2 (which is likely to be in BSC), and directly use AICH to send the negative acknowledgment to the MS. The MS then can re-start its preamble transmission again in order to send its message successfully to the BS, as shown in Figure 7.
- As BS will not indicate to BSC as shown in Figure 8 , the latency is reduced a great deal.

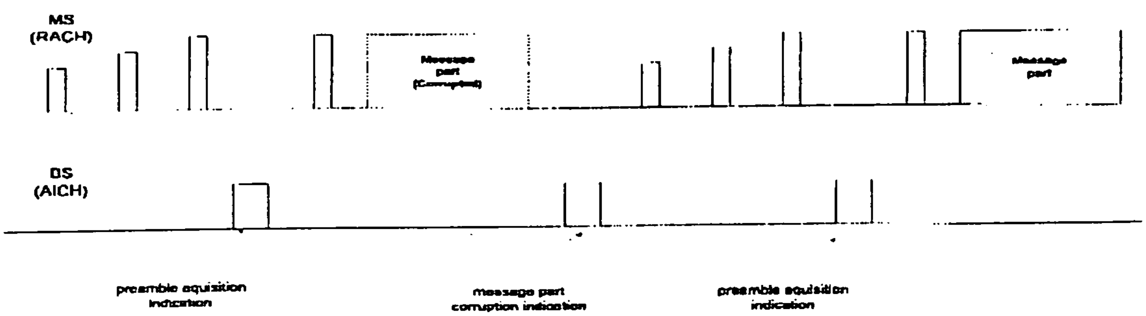

Figure 7: AICH used to acknowledge both preamble and message

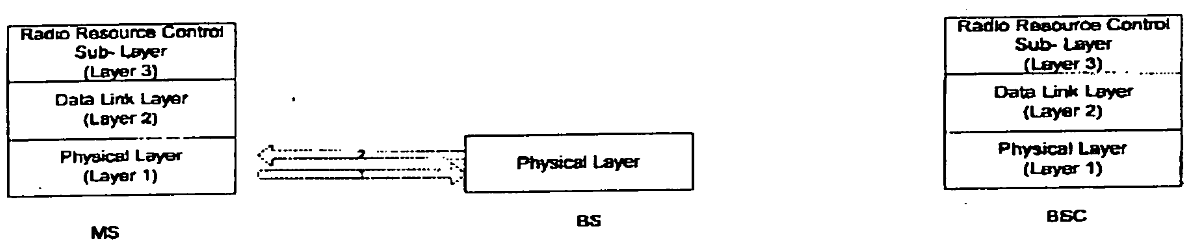

Figure 8: No indication to BSC

Therefore, the access procedure according to the improved technique should be :

1. After cell search and synchronisation, the MS reads the Broadcast Control Channel BCH to get information about:

- The preamble spreading code(s)
- The available signatures
- The available access slots
- The available spreading factors for the message part
- The uplink interference level in the cell
- The primary CCPCH transmit power level

2. The MS selects a preamble spreading code and thus the message scrambling code.
3. The MS selects a preamble signature and use it to determine the primary node of the channelisation codes used by the message part of the access burst.
4. The MS selects a channelisation code (corresponding to a spreading factor) for the message part.
5. The MS estimates the downlink path loss (by using information about the transmitted and received power level of the primary CCPCH), and determines the required uplink transmit power (by using information about the uplink interference level in the cell).
6. The MS implements the dynamic persistence algorithm by:
   - Reading the current dynamic persistence value from the BCH.
   - Perform a random draw against the current dynamic persistence value.
   - Defer transmission for one frame and repeat step 6 if the result of the random draw is negative, otherwise proceed to step 7
7. The MS randomly selects an access slot from the available access slots.
8. The MS transmits its preamble at a negative power offset relative to the estimated uplink transmit power.
9. The MS waits for an acquisition indication (on the AICH) from the network side. If none is received within a predefined time-out period, the MS transmits the preamble again but with a smaller power offset and a re-selected preamble signature.
10. Step 8 is repeated for a predetermined number of retransmission or until an acquisition indicator is received from the network side that indicates the acceptance by the network side of the preamble at that power offset.
11. If an acquisition indicator is received on the AICH in Step 9, the random access burst is transmitted in the next available access slot.

12. A negative acknowledgement will be sent on AICH in BS if the reception of the message part is CRC checking failure. step 5 onwards is repeated. If there is no such a negative acknowledgement is sent on the AICH, MS can assume that the RACH transmission is successful.

Improvement 2: Use of multi-state AICH to schedule message transmission

To reduce latency and mimimise H/W redundancy at the BS, we propose to use AICH to transmit message transmission scheduling information to the MS.

- At present the prior art includes only 2 states to the AICH :
  - State 1 indicates NO preamble with a given signature was detected.
    - In response to this, the MS re-transmits its preamble according to the procedure stated previously.
  - State 2 indicates A preamble with a given signature was detected.
    - In response to this, the MS transmits its message part (with or without a preamble) at a fixed time offset from its previous detected preamble transmission.

The problem with the above method is that it requires the BS to have sufficient H/W redundancy to always be able to process the message parts of all detected preambles. This adds a high cost to the BS and limits the number of access slots and preamble signatures allowed per BS to achieve a given throughput.

- This improved technique proposes adding an extra state to the AICH to indicate ideal scheduling time. Two variants of this state are proposed below.
  - State 3 (Variant 1) indicates A preamble with a given signature was detected but that NO H/W resources at the BS are free for immediate message processing – see figure 9.
    - In response to this, the MS re-transmits its preamble signature according to the procedure stated previously but at the same power, effectively 'stalling' its message transmission until a State 2 AICH is received.
  - State 3 (Variant 2) indicates A preamble with a given signature was detected and that H/W resources at the BS are free for message processing after a certain timeout 'T_{offset}' – see figure 10.
    - In response to this, the MS re-transmits its preamble signature and message but only after the indicated T_{offset} time-out.

- NOTE that State 2 can be considered as a sub-state of this variant of state 3.

- This improved technique allows the BS to more efficiently time-multiplex hardware resources for RACH message part processing, thereby increasing RACH throughput for a given amount of BS H/W.

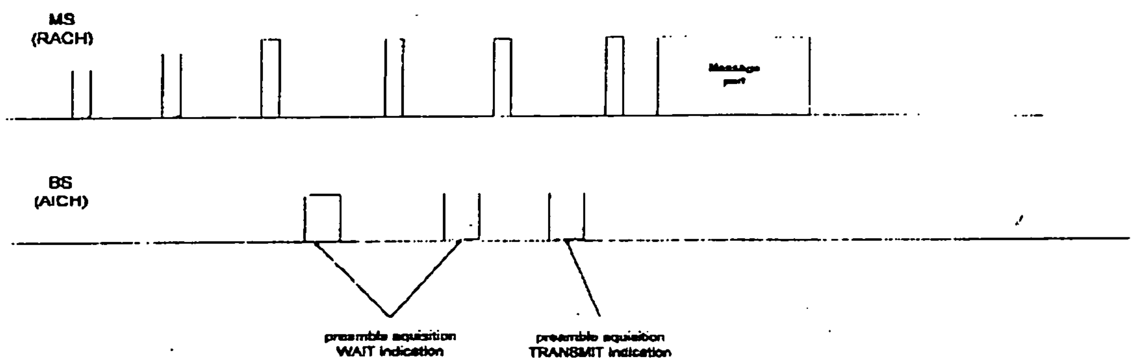

Figure 9: AICH used to Stall message transmission

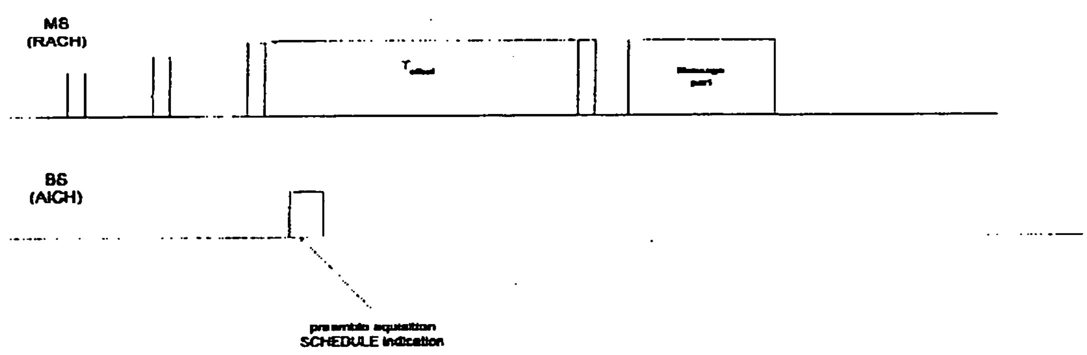

Figure 10: AICH used to Schedule message transmission

Therefore, the improved access procedure is preferably :

1. After cell search and synchronisation, the MS reads the Broadcast Control Channel BCH to get information about:
   - The preamble spreading code(s)
   - The available signatures
   - The available access slots
   - The available spreading factors for the message part
   - The uplink interference level in the cell

- The primary CCPCH transmit power level

2. The MS selects a preamble spreading code and thus the message scrambling code.

3. The MS selects a preamble signature and use it to determine the primary node of the channelisation codes used by the message part of the access burst.

4. The MS selects a channelisation code (corresponding to a spreading factor) for the message part.

5. The MS estimates the downlink path loss (by using information about the transmitted and received power level of the primary CCPCH), and determines the required uplink transmit power (by using information about the uplink interference level in the cell).

6. The MS implements the dynamic persistence algorithm by:

   - Reading the current dynamic persistence value from the BCH.
   - Perform a random draw against the current dynamic persistence value.
   - Defer transmission for one frame and repeat step 6 if the result of the random draw is negative, otherwise proceed to step 7

7. The MS randomly selects an access slot from the available access slots.

8. The MS transmits its preamble at a negative power offset relative to the estimated uplink transmit power.

9. The MS waits for an acquisition indication (on the AICH) from the network side.

   - If STATE 1 is received within a predefined time-out period, the MS transmits the preamble again but with a smaller power offset and a re-selected preamble signature.
   - If STATE 2 is received within a predefined time-out period, go to step 11.
   - If STATE 3 (Variant 1) is received within a predefined time-out period, the MS transmits the preamble again but with the same power offset and preamble signature.
   - If STATE 3 (Variant 2) is received within a predefined time-out period, go to step 11 after the time-out indicated by the AICH.

10. Step 8 is repeated for a predetermined number of retransmission or until an acquisition indicator is received from the network side that indicates the acceptance by the network side of the preamble at that power offset.

11. If an STATE 2 acquisition indicator is received on the AICH in Step 9, the random access burst is transmitted in the next available access slot.

12. A negative acknowledgement will be sent on AICH in BS if the reception of the message part is CRC checking failure. step 5 onwards is repeated. If there is no such a negative acknowledgement is sent on the AICH, MS can assume that the RACH transmission is successful.

In the prior art, the acquisition indicator is used to indicate the successful reception of the preamble by the BTS. In this improved technique, we extend the use of the acquisition indicators as a way of monitoring the usage status of the available preamble signatures.

As discussed above, in the conventional technique the following procedure is used during a RACH transmission, and can be turned the 'conventional RACH transmission steps':

1. After cell search and synchronisation, the MS reads the Broadcast Control Channel BCH to get information about:
   - The preamble spreading code(s)
   - The available signatures
   - The available access slots
   - The available spreading factors for the message part
   - The uplink interference level in the cell
   - The primary CCPCH transmit power level
2. The MS selects a preamble spreading code and thus the message scrambling code.
3. [redacted]
4. The MS selects a channelisation code (corresponding to a spreading factor) for the message part.
5. The MS estimates the downlink path loss (by using information about the transmitted and received power level of the primary CCPCH), and determines the required uplink transmit power (by using information about the uplink interference level in the cell).
6. The MS implements the dynamic persistence algorithm by:
   - Reading the current dynamic persistence value from the BCH.
   - Perform a random draw against the current dynamic persistence value.

- Defer transmission for one frame and repeat step 6 if the result of the random draw is negative, otherwise proceed to step 7

7. The MS randomly selects an access slot from the available access slots.

8. The MS transmits its preamble at a negative power offset relative to the estimated uplink transmit power.

9. **The MS waits for an acquisition indication (on the AICH) from the network side. If none is received within a predefined time-out period, the MS transmits the preamble again but with a smaller power offset and** [redacted].

10. **Step 8 is repeated for a predetermined number of retransmission or until an acquisition indicator is received from the network side, which indicates the acceptance by the network side of the preamble at that power offset.**

11. If an acquisition indicator is received on the AICH in Step 9, the random access burst is transmitted in the next available access slot.

12. A positive acknowledgment will be sent on FACH the network side to the MS if the reception of the message part is successful. If no acknowledgment is received by the MS, Step 5 onwards is repeated, until a positive acknowledgment is sent out on FACH from the network side.

In the prior art, the acquisition indicator is used by the BTS only to indicate to the mobile the successful reception of its preamble as highlighted by the bold writing in Section **Error! Reference source not found.**. If no acquisition indicator is received by the mobile, a different preamble signature is selected from the available signatures broadcast by BCH, **however without knowledge of the usage status of each of the available preamble signatures.**

It is important to have the knowledge of the usage status for each available preamble signatures:

- Reduce unsuccessful preamble detection by the BTS
- Reduce unsuccessful decoding of message by BTS

The end result is that it improves the usage efficiency of the RACH channel.

Improvement 3: Acquisition Indicator Sense for usage status of Preamble Signatures

In the improved technique, each switched-on mobile records the usage status of the available preamble signatures by monitoring all the acquisition indicators on the AICH channel. When the mobile decides to

send information (either control or data) on the RACH channel, it checks the usage status of each available preamble signatures and selects the least-used signature. At every retransmission of the preamble (if necessary), this will be done prior to the selection from the available preamble signatures.

Changes in the procedure (shaded parts in 'conventional RACH transmission steps'):

1. First shaded part should be replaced by:
The MS checks the usage status of each available preamble signatures prior to selection of a preamble signature. The selected signature is then used to determine the primary node of the channelisation codes used by the message part of the access burst.

2. Second shaded part should be replaced by:
...... a re-selected preamble signature with the least-used usage status.

Examples of the possible contents of usage status:

- Preamble signatures used by the stalled state (if multiple states acquisition indicator is used) and avoid selecting them during selection of preamble signature
- Statistics of the usage of each of the available preamble signatures and avoid using preamble signatures with high probability of usage.

Claims

1. A method of acquiring a message on a random access channel substantially as described herein with reference to the description and/or the accompanying drawings.
2. Apparatus adapted to acquire a message on a random access channel substantially as described herein with reference to the description and/or the accompanying drawings.